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APPLICATION OF THE RECIRCULATING GAS-TUBE FIRING SYSTEM TO CONTINUOUS DECORATING KILNS*

By Philip Dressler

Abstract

In 1936, recirculating-type gas tubes, fired by a Kemp carburetor system, were substituted in a continuous decorating kiln for electric heating elements. Operating results, after a six months' period, established the equivalent gas and electricity requirements and showed satisfactory operating results. A second continuous kiln fired by the same system has also been constructed. The application of heating to different types of circular and straight kilns is discussed.

I. Introduction

In the Kiln Firing Symposium at the Thirty-Eighth Annual Meeting of the American Ceramic Society, the possibilities of using gas-tube heating for decorating kilns were discussed. At that time no such application had been made. In the fall of 1936, a continuous decorating kiln[1] was equipped with the recirculating type of gas-fired tubes. This kiln has been in operation with this system of firing since October, 1936, and has yielded consistently good results. Operating data have been accumulated which serve as a useful guide as to what can be done with this method of firing decorating kilns.

Internally gas-fired metallic tubes have been used for a number of years in other industries where it is desirable to maintain, surrounding the material under treatment, an atmosphere which is entirely independent of combustion.

Muffles are no novelty in the ceramic industry. From the earliest days, attempts have been made to shield the ware from the gases of combustion. The refractory muffles used have not been entirely satisfactory because of the difficulties of securing a leak-tight joint construction and, furthermore, the muffle materials are themselves porous, permitting at higher temperatures a more or less rapid diffusion of gases through the thickness of the refractory. While in many cases this has offered no serious handicap to the successful use of refractory muffles yet, particularly in the case of overglaze decorations, it has been found that even small amounts of the products of combustion and water-vapor in the atmosphere surrounding the ware affect the quality of the decoration.

The industry has, to some degree, turned to the use of electricity as the heating medium in decorating kilns. Electric heat differs from that derived from the combustion of fuel in that the heat is developed with no products of combustion, and the treatment can be carried out, either in pure air or in any artificially prepared atmosphere.

Where it is desired to keep metals free from surface oxidation during heat-treating or annealing operations, electric heating has been rather generally adopted in the metallurgical industries. A number of furnaces have also been installed, in which internally gas-fired tubes have been substituted for electric heating elements. These tubes are made of high-grade heat-resisting alloys. They are formed without joints inside the furnace and are substantially gas-tight, so that, under normal operating pressures and temperatures, there is no appreciable leakage of gases in or out of the tubes.

The system of heating by means of metal tubes in which gas flames are burned is by no means novel. Within the limitations of temperature to which the ordinary steels and cast iron can be exposed, such installations have been made in the last ten or fifteen years, for instance, in the baking industry and for melting fusible metals by submerged heating elements. Studies of the combustion requirements combined with the development of refractory alloys have permitted a satisfactory life to be obtained at temperatures used in the ceramic industry. A number of installations have been made recently for a variety of heating operations at temperatures up to 1850°F.

II. Avoiding Local Heating

The principal difficulty to be overcome in working out internally gas-fired tubes has been the avoidance of local heating effects.

Any system of combustion which produces a localized zone of heat intensity at the burner or in any other spot in the tube, is unsatisfactory

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Art Division). Received August 4, 1937.

[1] At the plant of the Onondaga Pottery Company, Syracuse, N. Y.

because (*a*) local overheating of the tube takes place and shortens the life of the tube and (*b*) unequal heating of the ware is experienced owing to varying temperatures on the surface of the tube.

In general, the following methods have been worked out for this problem: (1) by means of a stratified gas and air mixture, a slow combustion is obtained, which spreads the flame throughout the whole length of the tube, and (2) by means of a high velocity jet of gas and air mixed intimately in the correct ratio and burning in a tube having the form of a closed loop, suitably vented to discharge products of combustion, a rapid recirculation of gases is produced which has the result of spreading evenly the heating effect over the full length of the tube.

After considerable investigation and experimenting, the second method, which seems to offer the most satisfactory means of heating internally gas-fired tubes, has been adopted.

III. Heating by Radiation

The type of heat provided by gas tubes is similar to that produced by electric heating elements. It consists solely of radiation from the hot surfaces of the tubes plus the natural convection movements of the atmosphere surrounding the tubes and the ware, which can be accelerated by the use of fans. Electric furnace designers have studied rates of heat emission and of the maximum heat output per square inch of heating surface which will avoid excessive differentials of temperature between the heating surface and the heated material. Where such excessive differentials are found, the so-called "toasting" effect is noticeable. Where they are avoided, no inequalities in heat treatment are apparent.

IV. Radiant Tube Decorating Kiln

Figure 1 shows the layout of the continuous decorating kiln at the Onondaga Pottery Company. The kiln is provided with a conveyer system, comprising a series of alloy rollers carried on alloy supports placed on the floor of the kiln. Alloy trays are passed through the kiln on these rollers. Each tray is 3 feet wide and 2 feet 8 inches long, with a loading height of 1 foot 3 inches. In the original construction of the kiln, there were provided beneath the roller hearth 16 pockets, each approximately 2 feet wide. Above the load, there were likewise provided 8 pockets, formed in the construction of the crown. In these pockets were located electric heating elements, of which 11 were in use beneath the roller hearth and 2 in the space above the ware. The heating elements were removable and interchangeable and were of two capacities, 9 and $14^1/_3$ kilowatts. The pockets were of such size that it was a simple matter to substitute 3-inch recirculating gas tubes for the electric heating elements without making any structural changes whatever in the kiln.

(1) Recirculating Gas Tubes

Twenty recirculating tubes have been installed in the kiln, of which 14 are on the lower level and 6 above the ware. For purposes of control, these are divided into three groups, the first comprising Nos. 1 to 6 on the bottom of the kiln and Nos. 17 and 18 on the top. This group is automatically controlled as a single unit from a thermocouple inserted through the crown of the kiln. The exhaust gases from the six bottom tubes are connected into a single manifold and pass through a system of steel pipes beneath the roller conveyer between the first pocket and the entrance of the kiln. Dampers are provided permitting as much of this heat as may be needed to be applied at the beginning of the firing operation. It has been found that a very slow heat increase is essential where elaborate decorations are being fired, involving several layers of size in the decal. Dial valves

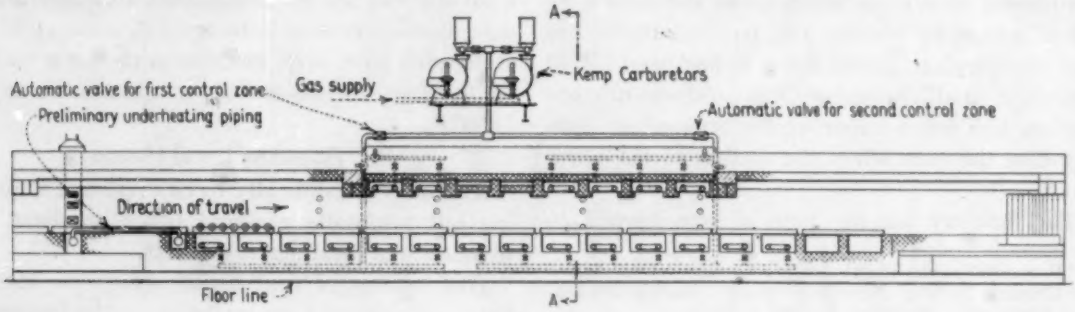


FIG. 1-*A*.

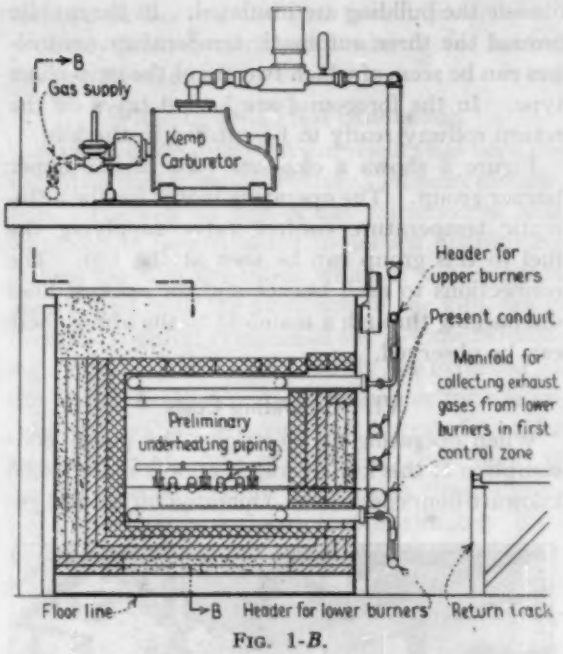


FIG. 1-*B*.

are provided, by means of which the distribution of fuel between the top and bottom tubes can be varied as desired.

The second group of tubes comprises Nos. 7 to 14 on the bottom of the furnace. This is independently automatically controlled from a thermocouple beneath the load.

The third group comprises top tubes, Nos. 21 to 24, and is also independently automatically controlled from a thermocouple in the ware space above the load.

V. Gas-Air Mixture Control

The gas-air mixture is supplied to the tube burners from a Kemp carburetor located on a platform above the kiln. The Kemp system is one which has been utilized for a number of years to supply an accurately controlled intimate mixture of gas and air.

It is not practical to sustain combustion, especially at lower temperatures in a stream of products of combustion unless the mixture of gas and air is extremely intimate. If it is not, the flame is snuffed out. With the system of mixing described, it is entirely possible to sustain combustion with the burner plunged beneath the surface of water. In fact, this method is not infrequently used for evaporation. The air-gas ratio is held within precise limits so that there is no difficulty in maintaining a product of combustion analysis showing no trace of unburnt gases and containing but 0.2% free oxygen.

Figure 2 shows the arrangement of the Kemp carburetor. Gas is supplied to the intake of the mixing fan through a zero governor. Air is drawn directly from the atmosphere through an air filter. The air and gas pass into a ratio valve by means of which the proportions are held constant regardless of the volume discharged by the mixing fan. On the outlet side of the fan there is provided a back-fire arrester, which serves to prevent an explosion wave from passing back into the fan should the mixture in the line become ignited. Beyond this is a mercury gage and a pilot flame. The latter permits visual adjustment of the mixing valve. With experience, it is not difficult to adjust the gas-air ratio to almost theoretical perfection by observation of the pilot flame. The gas-air mixture is delivered by the fan at a pressure of approximately 20 ounces. It passes through a regulator which holds the pressure constant at 17 ounces, regardless of the volume of fuel consumed.

(1) Burners

Figure 3 shows the equipment at each burner, which comprises a dial valve, back-fire arrester, and mercury pressure gage. In order that the injection force of the fuel leaving the burner head shall produce the maximum effect in recirculating the gases, the head is placed, not at the outside end of the tube, but adjacent to the return loop. Both the head and the supply pipe are insulated within

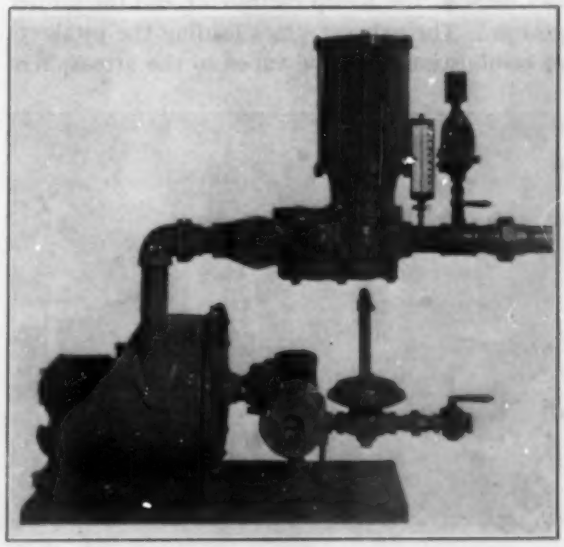


FIG. 2.

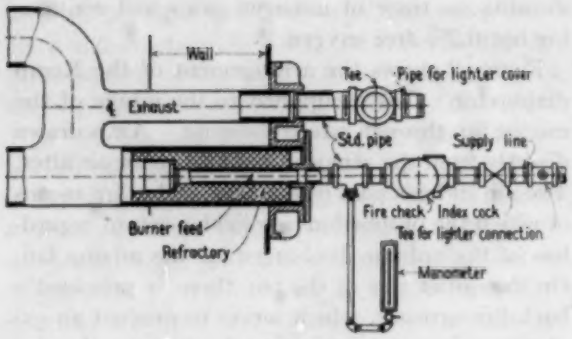


FIG. 3.

the tube. Each individual burner can be adjusted to give the desired fuel input by means of the dial valve, the effect of increasing or decreasing the fuel being shown on the mercury gage. Burner heads of various capacities are available, and for each position a burner head is chosen which will normally operate between pressures of 10 ounces and 20 ounces, in this way securing a satisfactory rate of recirculation of the gases in the tube. While the precaution is taken to equip each individual burner with a back-fire arrester to prevent the passage of an explosion wave through the supply piping, as a matter of fact, backfires are extremely rare and can result only from the improper manipulation of the system, and even when they do occur nothing more serious is involved than renewing a fusible link and resetting the back-fire arrester.

Figure 4 shows a view taken from the entrance end of the decorating kiln. In the background can be seen the Kemp carburetor and the burner groups. The exhaust pipes leading the products of combustion from the tubes to the atmosphere

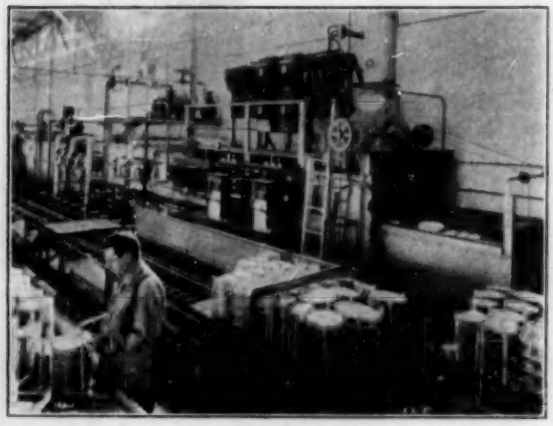


FIG. 4.

outside the building are insulated. In the middle ground the three automatic temperature controllers can be seen, of which two are of the strip-chart type. In the foregound are loaded trays on the return rollway ready to be entered in the kiln.

Figure 5 shows a close-up view of the upper burner group. The operating motor for the automatic temperature control valve supplying the fuel to this group can be seen at the top. The connections to each burner and the exhaust lines discharging through a manifold to the atmosphere can be observed.

VI. Operating Costs

When operating on electricity the power consumption of this kiln averaged approximately 62.5 kilowatt-hours per hour. Operated on natural gas

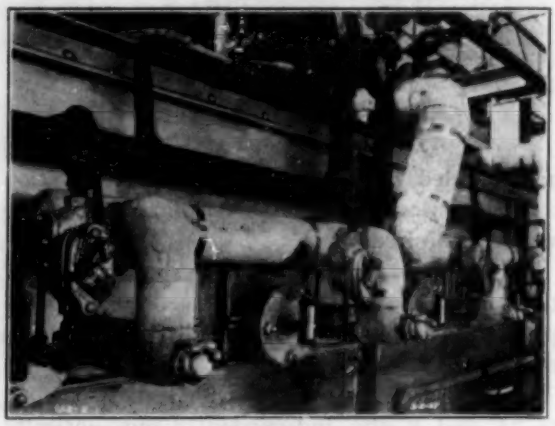


FIG. 5.

and firing the same ware on the same schedule, the fuel consumption is 370 cubic feet per hour, corresponding to 5.85 cubic feet of gas per kilowatt-hour. The gross British thermal unit value of the gas is 1020, the net value 920. If it is assumed that all the heat developed by the electric elements was utilized inside the kiln for heating the ware and to take care of radiation and conduction losses, then on the same basis, by calculation, 57.2 % of the gross heating value and 63.5 % of the net heating value of the natural gas are so utilized. The remainder represents the loss through the exhaust.

In the electric decorating of general ware, as manufactured in the larger potteries in the East Liverpool district, the power consumption per dozen is stated to be approximately 0.85 kilowatt-hour. The figures cited above would indicate that by the substitution of recirculating gas tubes

for electric heating the fuel consumption would probably run between 5 and 6 cubic feet of natural gas per dozen of ware.

VII. Uniform Heat Distribution

A remarkable uniformity of results has been obtained on the Onondaga Pottery Company installation. There is no sign of any variation of heat which could be attributed to uneven distribution of heat through the tubes, which it will be noted are all fired from the same side of the kiln, nor is there the slightest evidence of any so-called "toasting" effect. This would hardly be expected as the heat liberation per square inch of tube is exceedingly low. The actual heat liberated into the kiln is approximately 260,000 B.t.u. per hour, as can be calculated from the figures cited above. Each tube has a surface of approximately 1000 square inches so that inside the kiln there is, not counting the piping system at the entrance between the first tube and the door, a total heating surface of 20,000 square inches. The average heat emission is therefore approximately 13 B.t.u. per square inch per hour.

The temperature differences existing between the interior of the tubes and the ware have been explored in the furnace zone of the kiln. A thermocouple inserted through the crown between the tubes in positions 23 and 24,[1] with the junction located 1 inch from the top of the ware, shows a temperature of 1378°F. Thermocouples inserted into the interior of the tubes through the vents, through which the exhaust gases escape, gave readings of respectively 1404° and 1376° for tubes 23 and 24, or an average of 1390°. A thermocouple located above the center line of bottom tube No. 11, just beneath the roller hearth, showed a temperature of 1384°, while a thermocouple inserted into the interior of this particular tube gave a reading of 1428°. These readings indicate, between the temperatures taken inside the tubes and at points adjacent to the ware, a differential of 12° at the top of the load and of 44° under the load. The temperature differential below the load is naturally higher than that above on account of the greater concentration of weight in the metal trays.

VIII. Highly Efficient Heat Consumption

It will be noted from the foregoing figures that a remarkably high utilization, within the kiln, of the heating value of the fuel is achieved in this installation. This is principally attributable to the perfect gas-air ratio maintained by the system. There are no unburned gases in the exhaust. The free oxygen runs a few tenths of 1%. The importance of this can be judged by the consideration that every pound of excess air in the exhaust gases leaving the tubes at a temperature of 1400°F will carry out of the kiln about 325 B.t.u.

IX. Temperature Readily Adjusted

Another feature of this installation, which has proved highly satisfactory to the Onondaga Pottery Company, is the ability to carry any temperature desired in any portion of the firing zone, so that the heating can be adjusted, within practical limits to any desired curve. This results from the fact that the heating effect of each tube is independently controlled. There is no movement of products of combustion through the length of the kiln, which would tend to carry over effects from one zone to another.

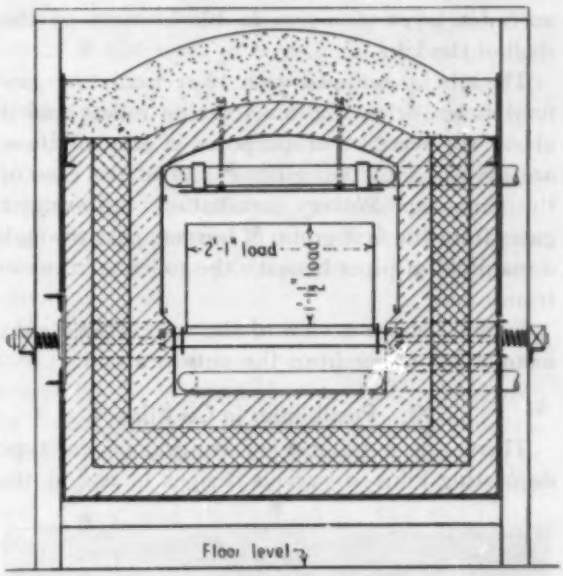


FIG. 6.

X. Lenox Continuous Decorating Kiln

At the present time there is under construction at the plant of Lenox, Incorporated, a continuous decorating kiln fired with recirculating gas tubes. This kiln is 50 feet in length and is of the roller-hearth type, having a series of rollers extending crosswise of the kiln carried on journals outside the kiln, and rotated simultaneously by an exterior chain drive.

[1] The two tubes at right top (Fig. 6).

The ware is carried on lightweight alloy trays, 2 feet 1 inch wide by 2 feet 3 inches long. The loading space is 13½ inches high. Figure 6 shows a cross-section of this kiln.

The rollers carrying the ware are made of refractory alloy in the center of the kiln and of cast iron at the ends. The trays are made very light because they are carried on driven rollers and are not required to push each other through the kiln. This permits the saving of a considerable amount of weight. The weight of each tray complete with expanded nickel grid is 19 pounds.

The kiln is constructed in accordance with modern electric furnace practice and is designed to reduce fuel consumption to a minimum. The lining consists of refractory insulating brick behind which is placed a layer of Superex blocks and an outer layer of magnesia blocks next to the shell of the kiln.

The kiln is equipped with 12 recirculating gas-fired tubes below the level of the rollers and 3 above the ware. For purposes of control these are divided into two groups. As in the case of the Onondaga Pottery installation, the exhaust gases from the first group of burners pass through a manifold of pipes beneath the rollers at the entrance end.

Figure 7 shows a view of the completed Lenox installation taken from the entrance end.

XI. Possibilities in Car Kilns

There are a number of continuous car-type decorating kilns of various designs in use in the ceramic industry. Many of these have now reached the stage where the operating results, from the standpoint of evenness of fire and fuel economy, leave much to be desired. While it is no doubt correct to state that the conveyer type of kiln, permitting the installation of heating units crosswise beneath the load, is superior to any car type, none the less it is possible to design recirculating gas tubes to take the place of muffles and still retain the use of cars. The recirculating gas tubes in this case are placed longitudinally of the kiln, being fired with right-angle burners. In such a remodeling, it is desirable to place the recirculating tubes at two levels so as to permit a greater concentration of heat beneath the loading platform.

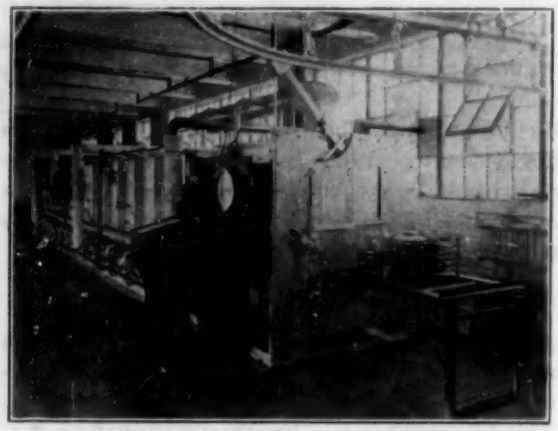


FIG. 7.

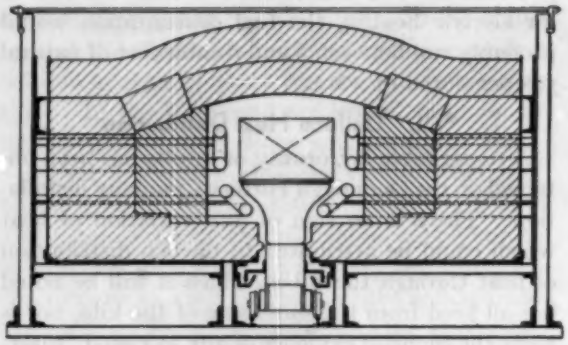


FIG. 8.

Figure 8 shows a cross-section of a car-type kiln modified in this fashion.

XII. Conclusions

An initial installation of recirculating gas-fired metallic tubes in a decorating kiln at the plant of the Onondaga Pottery Company has shown results equal in quality to those obtained with electric heat. On this installation it has been established that 5.85 cubic feet of natural gas are equivalent in heating value to 1 kilowatt-hour.

A second installation is being completed at the plant of Lenox, Incorporated, on a new, roller-hearth type continuous kiln.

The recirculating gas-tube system of heating can be applied to existing car-type continuous decorating kilns.

SWINDELL-DRESSLER CORPORATION
PITTSBURGH, PENNSYLVANIA

EXPERIMENTAL DETERMINATION OF FACTORS CAUSING STRAINS IN TRUE HARD-FIRE PORCELAIN FLATWARE AND A PRACTICAL MEANS FOR THEIR ELIMINATION IN PRODUCTION*

By R. E. Gould

Abstract

A description of the manufacture of thin, true porcelain flatware is given together with experiments which were carried on to determine the factors involving the strains. It was found that, by observing definite rules in the manufacture, a high percentage of straight flatware could be produced and maintained in full production. It was concluded that the manufacture of thin porcelain dinnerware in the United States by European methods would have a doubtful success, principally because of the expense involved in making flatware.

I. Introduction

True porcelain in the form of thin dinnerware has never been made in quantities with any great success in the United States although consumption of this type of ware has always been fairly great.

It appears at the present time that sales of this type of ware are still large, and, because manufacturing is now done in countries paying extremely low wages for skilled labor, the price of the finished foreign product has been reduced to the point where it is now even a competitor of the American-made, semivitreous ware.

True porcelain differs from other types of dinnerware mainly in bisque and glost fires. The bisque is fired to cones 010 or 09, where it becomes hard enough to be glazed without excessive breakage; the body and glaze are matured together under reducing conditions at the average temperature of cone 14, the reducing conditions starting at about cones 01 or 1. This is roughly the reverse of the china-type body procedure where the bisque is matured at cones 10 to 12 and the glost at cones 3 to 6, both operations requiring oxidizing conditions. In making thin dinnerware, the bodies are usually of the all-kaolin type because ball clay is very detrimental to color and especially to translucency. The final product, when made correctly, is beautiful and quite serviceable, particularly the glaze which, because of its high maturing temperature, is very hard.

The chief difficulty in the manufacture of porcelain flatware lies in holding this ware straight. Obviously, crooked plates are unsaleable, and the "straightness" of the plates materially influences a factory's reputation.

This paper is a presentation of data gathered from five years of practical factory research to find the factors influencing the tendency of flatware to become crooked or to stay straight. The results of the work in large-scale factory production over three years showed that thin flatware could actually be made straight. The problems encountered in the manufacture of true porcelain flatware are the same as those met in the manufacture of other types of ware, probably in a greatly exaggerated form, and it is hoped that some of the following results and conclusions will interest and benefit the trade.

Unlike vitreous ware of the various china types, true porcelain can not be supported on a preformed bed or by sand or other material between the pieces in a bung because the highest temperature in firing is used for the glost. If it is to be sold at a profit, each piece must stand on its own foot, shrink, and stay straight. For the better types of porcelain ware, a fair degree of translucency is demanded so that a certain degree of melting must take place in the body. A piece does not necessarily come from the glost kiln straight, even though it were good in the dried or low bisque stages, and a crooked dry or bisque piece will practically never straighten out in the glost fire. Unless some external force has been applied to the piece during the high firing process, the tendency of the piece to become crooked is almost wholly due to internal strains set up during the manufacturing process.

It is believed that the average well-run porcelain plant making thin dinnerware usually produces only from 30 to 50% of acceptably class 1 straight plates. This investigation was started with the hope that a study of fundamentals would result in the possible manufacture of 85 to 95% of commercially straight ware.

* Received April 30, 1937. This is a report of experiments carried out at the Giesche Porcelain Factory, Katowice, Poland.

II. Experiments

A preliminary investigation indicated that the following factors might be the most influential in the manufacture of straight flatware: (1) composition of the body and method of preparation, (2) variations in physical properties of plastic and dry body, (3) treatment of the plastic body prior to jiggering, (4) method of jiggering, *i.e.*, the method of forming, type of jigger tools, speed, etc., (5) method of forming the bat and pressing it upon the mold, (6) drying, (7) modeling of the plaster mold and the design of the plate, (8) firing, and (9) the sagger used in the glost fire.

With nine variables, it was decided to hold as many as possible constant so that the others could be studied; consequently, points (1), (2), (3), (7), (8), and (9) were controlled as much as possible.

The body used had the following composition: Zettlitz A-1 kaolin 50%, potash feldspar 25%, and quartz 25%. This body is typical, although in general practice such a high percentage of Zettlitz kaolin is seldom used because of the high purchase price. The fact that this kaolin does not vary in its physical properties, however, made it possible to hold the composition and properties of the body at a constant level. While this body was at first used only for experimenting with plates, it was gradually introduced and finally used for making even the cheapest types of mugs, etc., because it was found that with a body of constant quality, it was possible to make drastic reductions on all other production costs. The writer is convinced from this experience that manufacturers trying to save too much on raw materials and quietly accepting materials varying in physical properties are being "penny wise and pound foolish."

This body was prepared by ball milling the quartz and feldspar, which had previously been crushed upon a chaser mill, and part of the kaolin with water for twenty-two hours and then mixing this slurry with the rest of the kaolin in an agitator. The specific gravity and viscosity of the body slip and pressure in the filter press, as well as final preparation of the clay on wedging machines, were closely checked for any variation. Care was taken not to distort the clay rolls from the wedging machines but to transport them to the jiggering department on straight boards. The clay was cut from the rolls with wire for forming the bats which were made upon the spreader.

The method of jiggering followed the usual procedure, *i.e.*, the bat was spread on a piece of filter

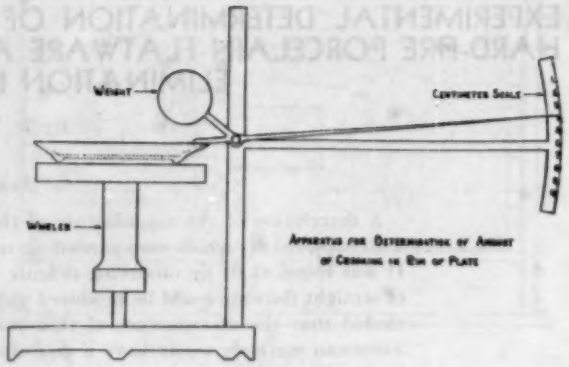


Fig. 1.

cloth, the filter cloth and bat were picked up from the spreader head, placed upon the plaster mold, the filter press cloth was peeled off, the bat "run down" by hand, using a sponge, and the excess clay jiggered off by a tool.

It appeared to be desirable at the start to define a plate which could be classed as "straight." Accordingly, a sorting apparatus, shown in Fig. 1, was constructed. Experiments with this machine showed that a variation in the edge of the plate of $^1/_{10}$ to $^1/_{12}$ centimeter from the horizontal plane was the maximum allowable limit. Plates showing this or less variation could be stacked without shuffling so that the bung appeared acceptable, even to the experienced and critical eye. Incidentally, while this machine was at first built expressly for the determination of experimental data, it was found of great benefit for the selection of plates for dinner service, and later all pieces were sorted in this manner. This was expecially valuable in making up shortages and matchings.

Flat, plain-edge, 24-centimeter dinner plates were chosen for trial, as experience had shown that these pieces were the most difficult to obtain in good selection. One hundred pieces per day from each jiggerman were carefully observed throughout the entire process. The percentage of straight and crooked plates was tabulated after each operation, and attempts were made to correlate the results thus obtained with the final results when the finished plates were selected by the machine. One thing of importance was quickly learned, namely, that a certain type of crook occurred in the glost fire where the foot had been raised on an uneven base or piece of grog or sand. The amount of rise in the edge of the plate due to this cause was apparent and greatly magnified. The aver-

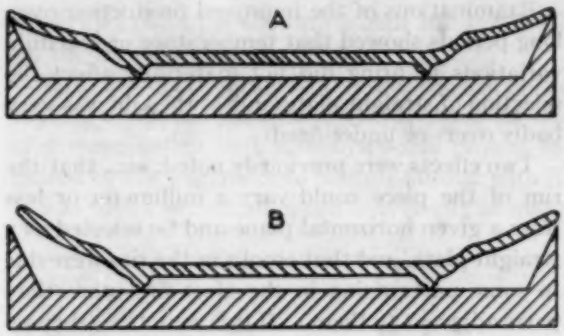


FIG. 2.—*A*, dry, green plate with rim and foot resting on setter made from same body as plate; *B*, fired plate and setter showing unequal rise of rim.

age number of straight plates was found to be from 15 to 20%. Placing each plate on a straight silicon-carbide setter coated with alumina increased the percentage of straight pieces to about 30% but still did not explain the high percentage of crooked pieces made from straight bisque and fired upon a straight setter.

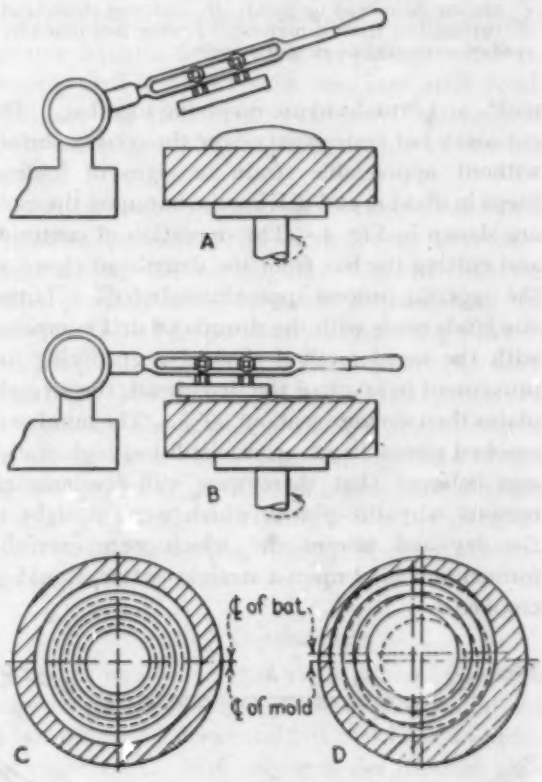
Bases of porcelain-plate body were then jiggered so that green plates placed within them would have their rims touching the edges and their feet resting on the bottoms. Such a base and plate are shown in Fig. 2*A*. It was thought that, being of the same composition, the base would shrink with the plate during the firing operation and would form a resting place for the rim which would necessarily be forced straight by gravity.

The astonishing result found in all trials so made was that the rim of the plate rose from the edge of the setter and remained straight or became crooked in the same proportion as had been previously observed. Typical conditions of this kind are shown in Fig. 2*B*.

It was obvious from these trials that the shrinkage of the rim of the plate was greater than the middle, causing the rim to become smaller in proportion to the center of the piece. Since in all cases the rim of the plate rose from the setter except in extreme cases where the firing operation caused excessive softening, it was possible to define a crooked plate as "a plate in which a part or parts of the rim rose during the glost fire higher than the parts adjacent to it." Examination of many pieces on the machine (see Fig. 1) showed the general condition to be that at least two places on the rim had risen more than the rest, probably indicating strains set up somewhere during the manufacturing process.

Suspicion was immediately placed on the operation where the bat is put upon the mold, since the spreading operation would conceivably induce strains in the bat similar to those formed in the jiggering process, and it would be a rare case where the bat and subsequent plate made from it were exactly concentric. Such a condition is shown in Fig. 3. Because the bats were made straight and then forced to assume a convex shape, it can be assumed that strains are induced into the rim when the piece is changed from flat to convex.

An easy way to overcome these two difficulties appeared to be the use of the well-known "drumhead" method of holding the bat. This drumhead consists of two brass hoops fitting tightly within each other and holding a diaphragm of filter cloth or other material in the same manner that skin is held on a drum. This diaphragm is placed on the spreader head and the bat spun on it. With this method, the bat may be removed from the spreader head without distortion, centered on the mold, and cut away from the cloth while the jigger,



— Line of strains induced in clay in bat forming
--- Line of strains induced in clay due to tool in jiggering

FIG. 3.—*A*, clay on whirler; *B*, tool spreading the bat; *C*, clay centered on mold; *D*, clay off center on mold.

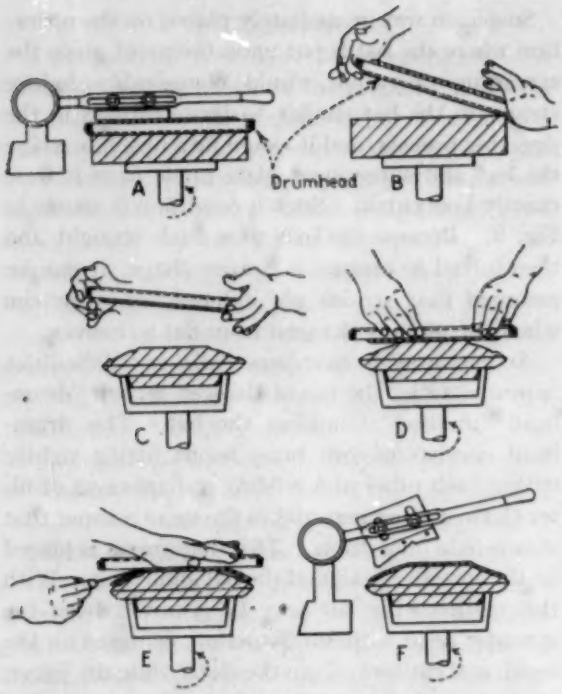


FIG. 4.—*A*, forming bat; *B*, removing drumhead; *C*, placing drumhead on mold; *D*, centering drumhead; *E*, cutting bat from drumhead; *F*, clay lies smoothly, ready for running down and jiggering.

mold, and drumhead are revolving together. The cut-away bat rests evenly over the convex surface without appreciable strain or signs of folding. Steps in making and placing the bat upon the mold are shown in Fig. 4. The operation of centering and cutting the bat from the drumhead slows up the jiggering process approximately 50%. Large-size trials made with the drumhead and compared with the usual method showed a gratifying improvement in favor of the drumhead, the straight plates then averaging about 50%. The number of crooked pieces, however, was still too high, and it was believed that there were still fundamental reasons why the plates, which were straight in the dry and bisque and which were carefully formed and fired upon a straight setter, would go crooked.

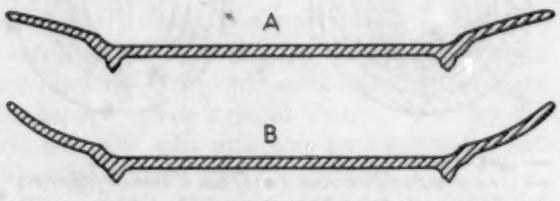


FIG. 5.—*A*, flat plate with little ball; *B*, deep plate with increased ball.

Examinations of the improved production over long periods showed that temperature or schedule variations in firing did not materially affect the selection of straight plates unless the kiln was very badly over- or under-fired.

Two effects were previously noted, *viz.*, that the rim of the piece could vary a millimeter or less from a given horizontal plane and be selected as a straight plate, and that crooks in the rim were due to some parts rising in the glost fire more than parts adjacent to them. If this were true, then reducing the amount of total rise of the rim would reduce proportionally the rise of the various parts of it caused by some strain and thus bring the variation within the allowable one millimeter limit. Accordingly, it was decided to study the factors which would influence the movement of the rim of the plate up and down during the firing process. After a thorough search, the following conditions were found to influence the rise and fall:

	Rise	Fall
(1)	Increasing "ball" in the model	Little or no "ball"
(2)	Weighting the rim on the piece during drying	Allowing the plate to dry without weighting the rim
(3)	Cutting edge upon the jigger tool	Compression edge on the jigger tool
(4)	High angle of slope on the rim or deep plate	Low angle or flat plate

Figure 5 illustrates point (1).

Figure 6 illustrates the method of weighting the rim with a plaster or metal ring. This ring must

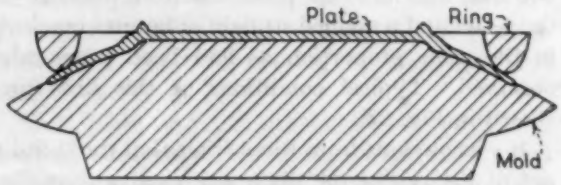


FIG. 6.—Cross-section of mold, freshly jiggered plate, and ring.

obviously not be so heavy that the plate will crack in drying. It must also be of the correct size so that it will just come to the edge when the drying shrinkage is complete.

Figure 7*A* shows the way the average plate tool is made. This is a "compression tool," for at least some part of the clay flows under the tool during the jiggering process. Figure 7*B* shows this condition reversed, where the clay is actually shaved or cut off to the desired profile. Figure 5

illustrates point (4) showing a high and low angle on the rim of the piece.

With a properly "run-down" bat, the use of the cutting tool is not appreciably harder than the use of a compression tool, although some time is required by the jiggerman to become familar with it. It was found better and more convenient to make

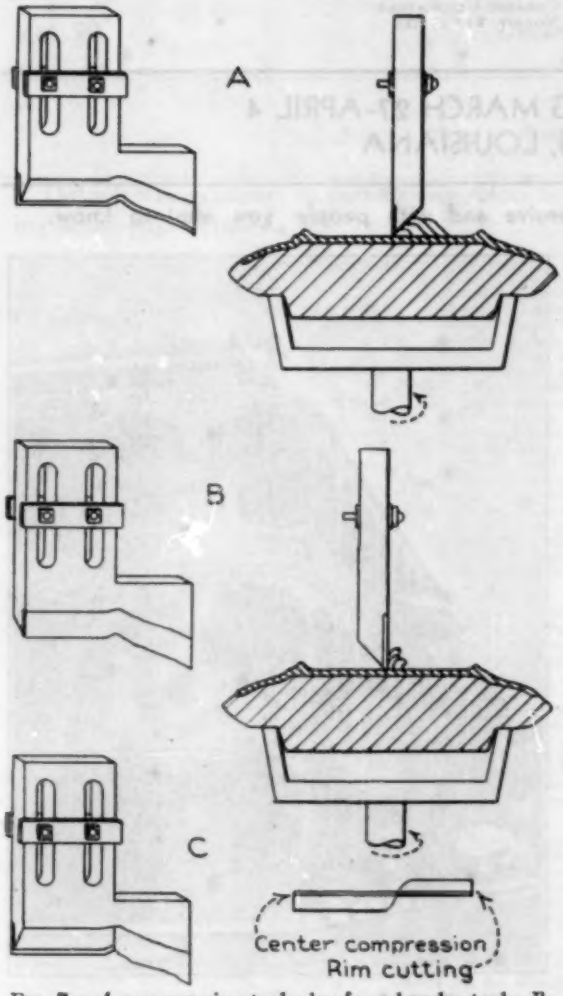


FIG. 7.—*A*, compression tool, clay forced under tool; *B*, cutting tool, clay shaved off; *C*, combination tool.

that part of the tool forming the rim of the plate cutting into the other part, beginning with the center of the foot to the center of the plate compression (Fig. 7*C*).

By combining the factors which influence rise and fall in the rim of the plate, it was found possible to obtain a practical combination whereby the tendency of the rim to rise during the high firing operation was counterbalanced by its tendency to fall, reducing the actual point movement of the rim to nearly zero, other than its normal shrinkage, *i.e.*, a plate was constructed as flat as possible with little or no ball using a cutting tool and weighting the rim when fresh with a plaster ring. Naturally the other factors previously found important were rigidly observed. Results as measured by the testing machine were very gratifying, the straight plates averaging more than 90%. When placed in full-scale production, it was found that an average of 87 to 95% could be easily and practically maintained.

It was first assumed that the improved but more expensive methods of jiggering should apply only to flatware going into dinner sets. All sizes and shapes of plates reacted well to the same rules as the 24-centimeter flat plates, and the percentage of good ware increased with a decrease in diameter as could be expected, especially on articles where the shape contributed to the structural strength, such as deep soup plates and saucers. It was later decided, however, to use at least some of the main points in making other types of flatware, and the slight increase in cost in jiggering was more than compensated for in the improved quality and greater demand. Heavier hotel plates reacted especially well and the results were extremely good. This fact was attributed to the heavier sections of the plate resisting the movement due to internal strains.

A study made to determine the effect of the other variables previously mentioned and kept constant during the investigation showed that the effect of fairly wide variation in processing the body during its preparation and handling prior to jiggering did not influence the final results more than 5%. Fluctuations in the physical properties of the body also appeared to be more influential on actual losses than on the straightness of the finished product, provided, of course, that changes in plasticity and workability could be compensated for by the jiggerman which is, unfortunately, not always possible.

III. Conclusions

(1) It was found that rigid adherence to the rules for making straight plates was successful not only from an experimental but also from a practical standpoint. Not only was the demand supplied by fewer jiggermen but the sales of dinner sets increased greatly owing to the improved quality.

(2) The minimizing of strains is the most im-

portant factor in manufacturing true porcelain flatware and appears to be accomplished best by hand labor. By observing all factors, only a few months were necessary to train a skilled man.

(3) For large-size dinner plates, a maximum production of 600 to 800 pieces per eight hours appears to be too low for the American scheme of mass production at high wages, although by improved production methods such as continuous stove rooms, etc., this figure could be raised.

(4) The sensitivity of the body and piece to strains indicates that successful automatic jiggering would be difficult unless the machine were excessively complicated and the plastic body of absolute constant physical quality.

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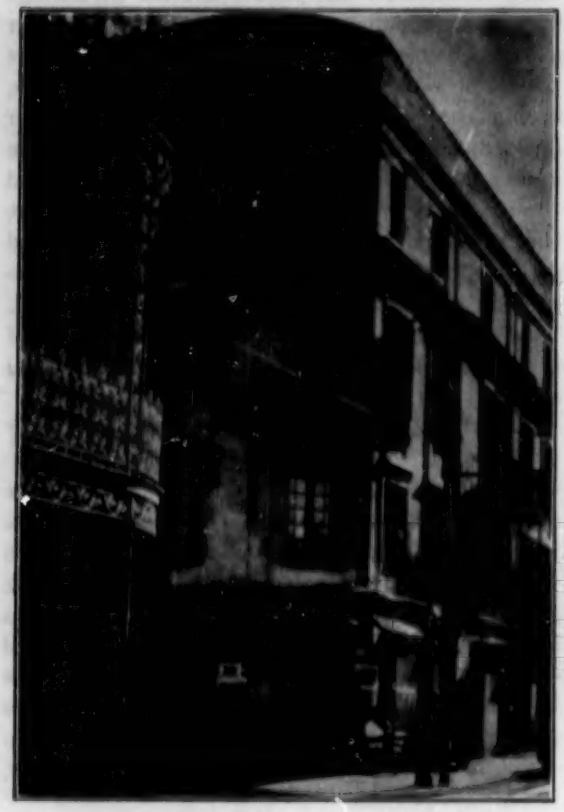

Sieur George Mansion, New Orleans

This colorful old home in the New Orleans Vieux Carre is known as the Le Monnier Mansion, the Sieur George Mansion, and the city's first skyscraper.

Construction on it was started in 1806. In 1811 a third story was added and a fourth in 1870. The initials of Dr. Le Monnier—Y. L. M.—can still be seen in the iron-girded balcony.

Originally there were four shops on the ground floor, six rooms on the second, seven on the third, and a garden on the roof. The courtyard was paved with Barsac stones.

It was in this building that George W. Cable domiciled his fictional character, "Monsieur George."

Embroidered Balconies

A striking characteristic of the architecture of New Orleans' Vieux Carre (French Quarter) is the myriad patterns in wrought and cast iron, giving that section its atmosphere of old France and old Spain.

This old home, on the corner of St. Peters and Royal Streets, was built about 1835 by Jean Baptiste Lafranche, a wealthy sugar planter, and occupies the site of a famous cabaret which was celebrated for the steaming cups of "cafe" served in the coffee shop. The ironwork design is entwined oak leaves and acorns.

Balconies, of which this one is tyipcal, were known to the Spanish as "miradors" and as "galeries" to the French. They are to be found on all Vieux Carre buildings of more than one story high. Some of them have the family initials forged in the ironwork design.

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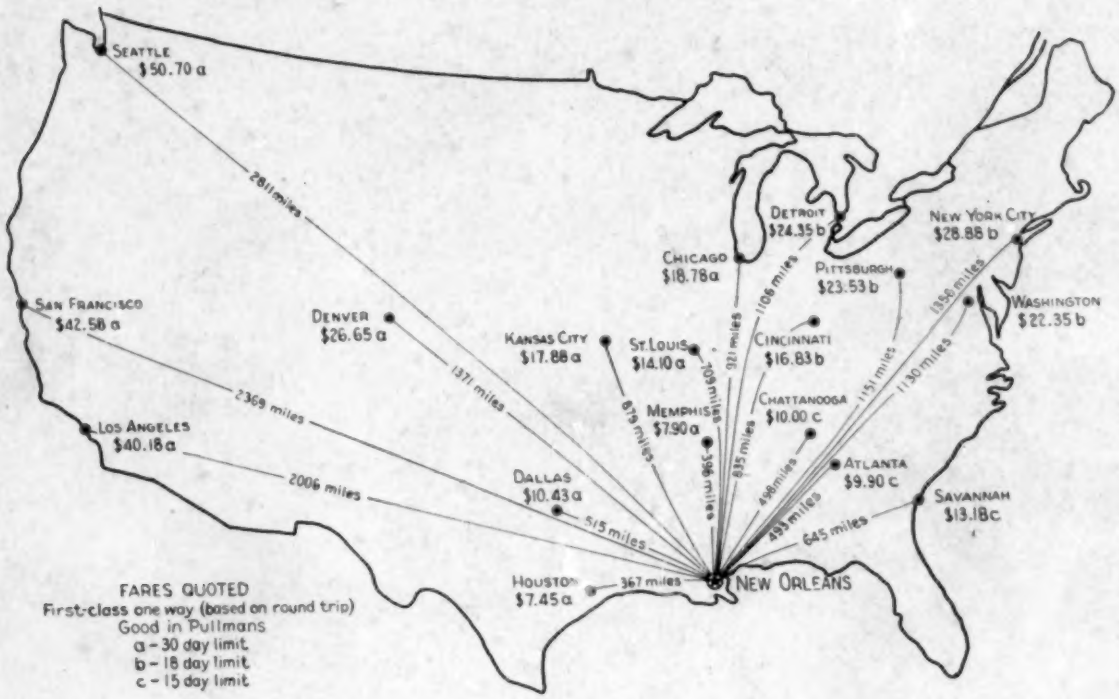

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